International Journal of Mechanical and Production Engineering Research and Development (IJMPERD)
ISSN(P): 2249-6890; ISSN(E): 2249-8001
Vol. 4, Issue 1, Feb 2014, 55-62

DESIGN & FABRICATION OF ABRASIVE JET MACHINING

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ABSTRACT

The paper aims at designing a set up for abrasive jet machining. Abrasive jet machining (AJM) is the process of material removal from a work piece by the application of a high speed stream of abrasive particles carried in a gas medium from a nozzle. The material removal process is mainly by erosion. The ajm will chiefly be used to cut shapes in hard and brittle materials like glass, ceramics etc.

KEYWORDS: Abrasive Jet Machine, Material Removal Rate, Design, Fabrication, Abrasiveses

INTRODUCTION

Last two decades have witnessed the development of a number of noval metal cutting processes which do not employ conventional cutting tools but make use of electrical, mechanical or chemical energy for mental maching. However application of these processes is justified only to materials[1] which are normally not machinable by usual methods. Many of the recent development in the aerospace and nuclear engineering industries and partly due to the increasing use of difficult to machine materials such as hastalloy, nitralloy, wadpalloy, nimonics, carbides, stainless steel, heat resisting steels etc. Many of these materials also find application in other industries owing to their high strength-to weight ratio, hardness and heat resisting qualities. The conventional machining processes, Inspite of recent technological advancements are inadequate to machine these materials from the standpoint of economic production. Besides, machining of these materials into complex shape is difficult, time consuming and sometimes impossible.

NON-TRADITIONAL MACHINING PROCESSES

These processes are non-traditional or unconventional in the sense that do not employ a conventional or traditional [2] tool from removal, instead, they directly utilize some form of energy from mental machining Non-traditional machining processes can be classified into various groups according to the type of fundamental machining they employ namely mechanical, electrical, chemicals, electro-chemical, thermo-electric, etc. The classification of the machining processes, based upon the type of energy used. In the Mechanical methods of non-traditional machining, the material is principally removed by mechanical erosion of the work-piece material[5]. The mechanical methods include[3].

- Abrasive Jet Machining (AJM)
- Water Jet Machining (WJM)
- Ultrasonic Machining (USM)

PRESENT WORK

Here in this paper we are interested in jet machining i.e. "ABRASIVE JET MACHINING". Utilizing the principle of erosion of material while being impinged on the work-piece surface by fine abrasive particles entertained in high velocity air or gas stream. AJM finds its use, this processes characterized by the power consumption, small capital investment and absence of contact between the tool and the work. The major filed of application of AJM process is in the machining of essentially brittle, hart resistant materials like glass, quartz, sapphire, semiconductor materials holes, cutting slots, cleaning hard surfaces cutting fine lines, debarring, scribing, grooving, polishing and radiusing. Delicate clearing such as removal of smudges from antique documents is also possible with AJM. Because of the accuracy and reliability of AJM some research Laboratories are using to test to test the abrasion resistant materials. Abrasive jet cutting is used in the laboratories to prepare surfaces for strain gauges application and to create artificial flaws in materials for calibration of testing equipment's[7].

PRINCIPLE OF OPERATION

In this process a focused stream of abrasive particles carried by high pressure gas or air at a velocity of about 150 - 180 m/sec are made to impinge on the work surface through a nozzle and the work material is removed by erosion by the high velocity abrasive particles. The abrasive particles should have regular shape and consist of shorpedges. The [4] abrasive particles are directed into the work surface at high velocity nozzle. The abrasive particles used were SiC (grain size 100 microns and 200 microns). Phe nozzle material was stainless steel and the nozzles used were of diameters 1 mm and 0.5 mm.

In this process the abrasive particles which I mpenges at high velocity erodes the metal or the work-piece. The small diameter of nozzle helps the abrasive to be focused and thus to cut very small section. Air or gas supplied with the abrasive jet acts as a carrier and also the heat removal agent. Because of this there is no thermal [6] strain occurred on the work, also there is no contact between tool and work. The process can be easily controlled by varying the parameters such as velocity pressure. Flow rate, stand of distance, particle size, etc.

PARAMETERS INVOLVED IN AJM (METAL REMOVAL RATE)

- Abrasives
- Abrasive particle size
- Abrasive jet velocity
- Carrier gas
- Mean number of abrasive particle per unit volume of gas
- Work material
- Type of cut
- Nozzle characteristics

CLASSIFICATION OF ABRASIVES

- Natural abrasives.
- Synthetic or manufactured abrasives

PROPERTIES OF ABRASIVES

Table 1: The Hardness of the Abrasive Material Affects the Metal Removal Rate and the Surface Finish of the Work Piece

S. No	Moh'scale Material	Knoop No
1	Talc	-
2	Gypsum	-
3	Calcite	-
4	Flurite	-
5	Apatile	-
6	Fledapar	560
7	Quartz	820
8	Topaz	1340
9	Corundum	1360
10	Diamond	8000

EQUIPMENT SET-UP

A schematic layout of AJM is shown in Figure The filtered gas, supplied under pressure to the mixing chamber containing the abrasive powder and vibrating at 50 c/s, entrains the abrasive particle and is the passed into a connecting hose. This abrasive and gas mixture emerges from a small nozzle at high velocity. The abrasive powder feed rate is controlled by the amplitude of vibration of the mixing chamber. A pressure regulator controls the gas flow and pressure. The nozzle is mounted on a fixture. Either the work piece or the nozzle is moved by cams pantograph or other suitable mechanisms to control the size and shape of the cut. Hand operation is sometimes adequate to remove surface contaminations or in cutting where accuracy is not very critical. Dust removal equipment is necessary to protect the environment. Commercial bench mounted units including all controls, motion producing devices, and dust control equipment are available. The working principle is shown.

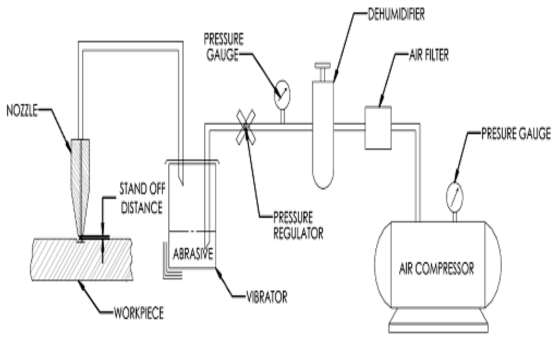


Figure 1: Schematic Layout of Abrasive Jet Machine

GRAIN SIZE

Table 2: Type of Grain Size

S. No	Abrasive Type	Grain size in Microns	Surface Finish in mm
1	Very Coarse	6 – 14	Above 0.9
2	Coarse	16 – 30	0.8
3	Medium	36 – 60	0.7
4	Fine	70 – 120	0.42 – 0.6
5 6	Very Fine Super Fine	150 – 240 280 – 580	0.22 – 0.4 0.05 – 0.02
7	Special	1000 (or above)	-

MATERIALS USED FOR PREPERATION OF ABRASIVE JET MACHINE

Table 3

S. No	Part Name	Material
1	hopper	mild steel
2	ball valve	stainless steel
3	y-pipe	mild steel
4	nozzle	stainless steel
5	frame	mild steel
6	nipple	mild steel
7	x-nipple	mild steel
8	t-slot	mild steel
9	bush	mild steel
10	wheel valve	brass
11	hose pipe	stainless steel
12	pressure gauge	
13	control valve	brass
14	bolts and nuts	mild steel
15	enclose	acryline

DESIGN PROCEDURE

As per the data collected from various references we came to a final drawing lay out of our project which is attached along with this project work. First we concentrated on the main powder feeding mechanism, i.e. hoppers (powder mixing chambers). From calculations we considered 16 gauge M.S. Sheet so as to withstand pneumatic pressure as high as 10 kg/cm^2, considering it as closed vessel. Then step by step we designed, then frame for that we collected it from college campus which is suitable for our set up. All the required calculations are presented here by fully.

FABRICATION PROCEDURE

We prepared cylindrical hopper from 16 gauge M.S. sheet. A nozzle is attached at the bottom of the hopper with the necessary provisions. Manufactured connections for pressure gauge. Hoses are arranged to provide air supply from the compressor to hopper and at the nozzle to mix with abrasive particles and to create a stream of jet for machining for pneumatic connections, nozzle and all parts are attached with nipples of pneumatic supply which are made of brass. The frame is manufactured by using mild steel by welding.

RESULTS AND DISCUSSIONS

1. **Design of Cylinder (Steel)**

Considering it as a closed cylinder of length $22cm$

Let P = Intensity of pressure = $\frac{10kg}{cm2}$

D = Internal diameter of cylinder = $15.5cm$

L = Length of the cylinder =$22cm$

T = Thickness of the cylinder=$0.7cm$

F_t= Ultimate hoop stress in the cylinder material = $1000\frac{kgf}{cm2}$

Factor of safety = $\mathbf{2}$

Therefore,

Allowable hoop stress = $\frac{500kg}{cm2}$

Using the relation,

$$T = \frac{PD}{2Ft}$$

T = (10*15.5)/2*500

T =$0.2cm\ i.e\ 2mm$

But we have selected a thickness = $2.5mm$

At 2.5mm thickness the hoop stress developed:

$$T = \frac{PD}{2Ft}$$

Or $Ft = \frac{pd}{2t}$

= $\frac{10 * 15.5}{2 * 0.7}$

= $\frac{110.71kg}{cm2}$

Therefore, actual hoop stress developed= $\frac{110.71kg}{cm2}$ the thickness of $0.7cm$ Where the allowable hoop stress is $\frac{500kg}{cm}$ .Therefore it is on safer side condition.

1.2 **Design of Cone**

Diameter of the cone $D = 17cm$

$$l = \frac{\sqrt{3}}{2} * D$$

= $\frac{\sqrt{3}}{2} * 17cm$

Length of cone=$14.72cm\ d = 3\ cm$

$$r = \frac{d}{2} = 1.5\ cm$$

$$Tan\ \alpha = \frac{b}{H}$$

$$b = \frac{D - d}{2}$$

$$= \frac{17 - 3}{2}$$

$$b = 7\ cm$$

$$Tan\ \alpha = \frac{b}{H}$$

$$= \frac{7}{14.72}$$

$$= 0.372cm$$

$$\alpha = \ 25.31º$$

$$c = \sqrt{b2 + h2}$$

$$= \sqrt{49 + 219.04}$$

$$= 16.37\ cm$$

$$e = \frac{r}{\sin\alpha}$$

$$= \frac{1.5}{\sin(25.31)}$$

$$= 3.50\ cmR = c + e = 16.37 + 3.50 = 19.87\ cm$$

1.3 **Design of the Cover Plate**

$Let\ , ti$ = Thickness of cover plate

di =Internal diameter of the cylinder=$20.5cm$

k= Empirical constant=0.162

$$p = 10\,\frac{kg}{cm2}$$

$$ft = Allowable\ stress = 500\,\frac{kg}{cm2}$$

Therefore,

$$t\,i = d\left(\frac{kp}{ft}\right)$$

$$= (15.5)\left(0.162 * \frac{10}{500}\right)$$

$$= 0.05cm = 5\ mm$$

But we have selected a thickness of $9\ mm$ .Because of safety purpose due to pressure

1.4 **Design of Stand**

For assembling, we have mounted all the parts on a stand, made up of angles. (A frame). The dimensions of the frame are

$height = 14.3cm,$

$Length = 3.5cm$

$Breadth = 3.8cm.$

1.5 **Design of Nozzle (ss)**

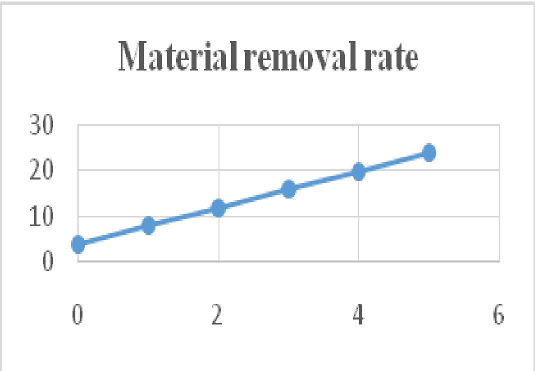
$Length = 4.5cm = 45mm$

$Outer\ diameter\ of\ nozzle = 1\ mm$

$Inner\ diameter\ of\ nozzle = 0.98\ mm$

$Nozzle\ tip\ distance = 0.81\ mm$

EFFECT OF PRESSURE ON MATERIAL REMOVAL RATE



Graph 1: The Log Plot of Material Removal Rate and Pressure as Shown Gives a Slope

Work material	: Glass
Abrasive	: SiO2
Particle Size	: 200 Mesh
Abrasive Flow Rate	: 10gm /min
Stand of distance	: 3mm

BRIEF OBSERVATIONS

Table 4

S. No	Parameter	Type
1	Medium	Air, Gas
2	Abrasive	sio2(100-200microns)
3	Pressure	2-10kg/cm2
4	Nozzle size	0.05-1mm
5	Material of nozzle	Stainless steel,shapide,tungstein carbide
6	Nozzle work distance	0.25-15mm
7	Depth of cut	0.5-3.85mm

CONCLUSIONS

In this paper it is discussed about the type of air jet machine which is designed fabricated and tested different parameters like material removal rate, size of the abrasive particles, type of material used for the fabrication.

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